

SEMI F32-0706

TEST METHOD FOR DETERMINATION OF FLOW COEFFICIENT FOR HIGH PURITY SHUTOFF VALVES

This standard was technically approved by the global Gases Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on May 16, 2006. It was available at www.semi.org in June 2006 and on CD-ROM in July 2006. Originally published in 1998.

1 Purpose

- 1.1 This test method describes how to determine two criteria used in selecting valves of appropriate size for gases and liquids.
- 1.2 Methods and equations are specified and/or referenced to assist in accurate calculation of pressure drops across valves tested by this method.

2 Scope

- 2.1 This method establishes the testing criteria for determination of two coefficients specified in ANSI/ISA-S75.02:

- Valve flow coefficient (C_v)
- Critical pressure drop ratio factor (x_T)

2.2 This method is to be used with ANSI/ISA-S75.02. This method applies to manual and actuated valves for use in both gas and liquid distribution systems used in semiconductor manufacturing facilities. It is a test method, where existing test methods are referenced and limitations are imposed on test conditions. Specific equations for calculating flow coefficients, choked flow parameters, and pressure drops are referenced to the appropriate ISA section.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

- 3.1 This method will limit the use and interpretation of ANSI/ISA-S75.02 for use by manufacturers and users of valves designed for the semiconductor industry.
- 3.2 This method is not intended to be used to determine flow coefficients for valves used in vacuum service.

4 Referenced Standards and Documents

4.1 *ANSI Standard*¹

ANSI/ISA-S-75.01 — Flow Equations for Sizing Control Valves

ANSI/ISA-S75.02 — Control Valve Capacity Test Procedure

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *Abbreviations and Acronyms*

- 5.1.1 ΔP — pressure drop across valve, kPa (psi)
- 5.1.2 F_k — ratio of specific heats factor, where:

$$F_k = \frac{k}{1.40}$$

¹ American National Standards Institute, Headquarters: 1819 L Street, NW, Washington, DC 20036, USA. Telephone: 202.293.8020; Fax: 202.293.9287. New York Office: 11 West 42nd Street, New York, NY 10036, USA. Telephone: 212.642.4900; Fax: 212.398.0023; Website: www.ansi.org

5.1.3 F_L — liquid pressure recovery factor

$$F_L = \frac{Q_{\max}}{0.0865 * C_v * \sqrt{\frac{P_1 - 0.96 * P_v}{S_f}}}$$

$$\left(F_L = \frac{Q_{\max \text{ gpm}}}{1.00 * C_v * \sqrt{\frac{P_1 - 0.96 * P_v}{S_f}}} \right)$$

5.1.4 gpm — gallons per minute

5.1.5 k — specific heat ratio

5.1.6 P_1 — absolute pressure at upstream pressure tap, kPa (psi)

5.1.7 P_2 — absolute pressure at downstream pressure tap, kPa (psi)

5.1.8 P_v — absolute vapor pressure of liquid at inlet temperature, kPa (psi)

5.1.9 $psia$ — pounds per square inch absolute

5.1.10 $psid$ — pounds per square inch differential

5.1.11 Q — volumetric flow rate

5.1.12 $Q_{\max}$ — maximum flow rate (choked flow conditions) at a given upstream condition

5.1.13 $scfh$ — standard cubic feet per hour

5.1.14 S_f — specific gravity of a liquid relative to water

5.1.15 S_g — specific gravity of a gas relative to air

5.1.16 T — absolute temperature of test gas or liquid, °K (°R)

5.1.17 x — ratio of pressure drop to absolute inlet pressure, dimensionless, where:

$$x = \frac{\Delta P_{kPa}}{P_{1kPa}} \left(x = \frac{\Delta P_{psid}}{P_{1psia}} \right)$$

5.1.18 x_T — ratio of pressure drop to absolute inlet pressure ($\Delta p/p_1$) at choked flow condition, dimensionless

5.1.19 Y — expansion factor for compressible fluids, where:

$$Y = 1 - \frac{x}{3 \times F_k \times x_T}$$

(Limits $1.0 \geq Y \geq 0.67$)

5.2 Definitions

5.2.1 *flow coefficient* C_v — a numeric constant used to characterize the flow capacity of a valve.

5.2.2 *vapor pressure condensation point* — pressure at which fluid phase changes from liquid to gas, for a given upstream condition.

5.2.3 *vena contracta* — point in a duct where the diameter of the fluid stream is smaller than the diameter of the duct.

6 Test Fluids

6.1 *Incompressible (Liquid) Fluid* — Water is the standard liquid test fluid.

6.2 *Compressible (Gaseous) Fluid* — Nitrogen is the standard gaseous test fluid. When using Nitrogen, care should be taken to assure that the fluid does not approach the vapor pressure condensation point at the vena contracta.

7 Test Setup

7.1 Test Valve

7.1.1 The test valve can be any high purity valve, or a combination of valve with tube connections, fittings connection, or expanders which are normally attached as part of the valve assembly as purchased. It is important to note that the definition of the “test valve” is inclusive of all connections and fittings, as supplied by the manufacturer. This specifically differs from the ISA procedure, whereby a method is provided to differentiate the pressure drop contribution of the attached fittings. It is recognized that flow coefficients may vary slightly depending upon the end connection used. Examples of typical test valves are shown in Figure 1.

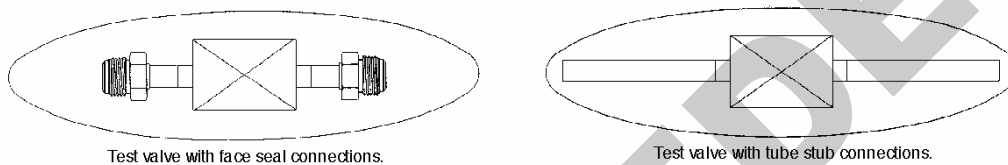


Figure 1
Test Valve with Various Connections

7.2 Test Section Requirements

7.2.1 Fixturing of the test valve shall be made in accordance with ANSI/ISA-S75.02, Table 1, where the test valve is the complete valve assembly including connections, as described above. For reference, ANSI/ISA-S75.02 test setup is shown in Figure 2.

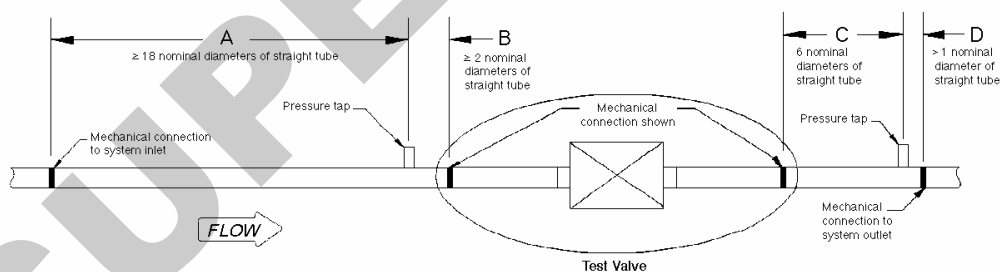


Figure 2
Fixturing Requirements, Standard Test Section

7.2.2 *Tube Connections* — Connections to the test valve are to be the same as would normally be performed by the end user as installed. Tube connections are to be full penetration welded by automatic orbital head, with purge gas.

7.2.3 *Face Seal Connections* — Face seal connectors supplied with the test valve may be either male or female. An appropriate mating connector shall be welded into the inlet and outlet tubing using full penetration orbital head welds, and connected to the valve with standard seals.

7.2.4 *Compression Fitting Connections* — Valves supplied with tube stubs may be connected with compression fittings.